Identifying the Neural Mechanism of Approach Behavior: studying the role of the superior colliculus in the mouse

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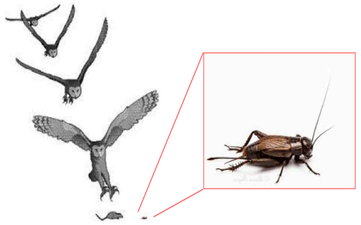
Introduction

Despite the importance of vision in mediating our behavior, we still understand relatively little about the mechanisms that allow us to correctly identify and appropriately respond to visual cues in our environment. Here, we use the mouse model to identify the specific areas and brain circuits required to promote accurate and efficient orienting behaviors during prey-capture. An understanding of how the mouse brain processes visual information in this context gives us a basic understanding of how mammalian brains in general process highly salient visual information. Such process may be impaired in neurological disorders like PTSD and addiction, which stem from visual stimuli triggering unhealthy or inappropriate responses.

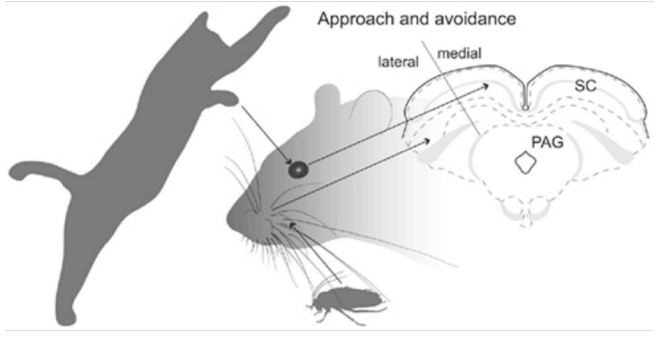
Prey-capture behavior



- Prey-capture is an innate, visually-directed behavior in many species that utilizes highly conserved basic visual functions such as object recognition and localization.
- The common house mouse can perform prey-capture behavior using vision. Therefore, we may use this powerful genetic model organism to gain a deeper understanding of how specific neuronal circuits in the mammalian brain processes highly relevant visual information.

Superior colliculus role in prey-capture

- The SC takes multimodal sensory input and directs a motor output
- Superficial layer of SC receives only visual input
- Medial SC directs avoidance in rodents, while lateral SC directs approach behaviors in rodents

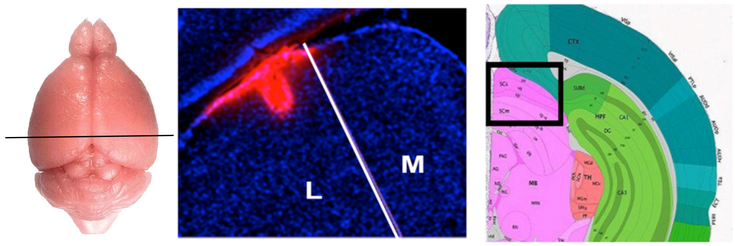


Questions and hypothesis

1. Does the SC play a role in prey-capture behavior in mouse?
2. If so, what specific cell types and neural circuits within SC specifically mediate approach behaviors towards important stimuli?

We hypothesize that inhibition of SC will perturb prey-capture behavior and inhibition of wide-field (WF) cell types in SC will modulate orientating behavior.

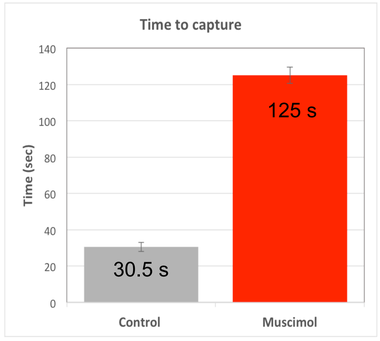
Targeting muscimol inactivation to superior colliculus



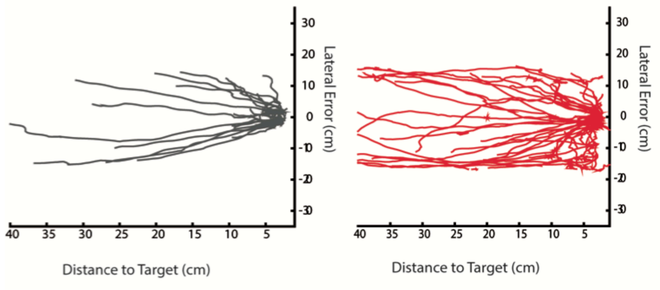
- We analyzed behavioral data from mice where muscimol was successfully targeted to lateral and superficial superior colliculus as shown above.

Inactivation of lateral SC impairs prey-capture

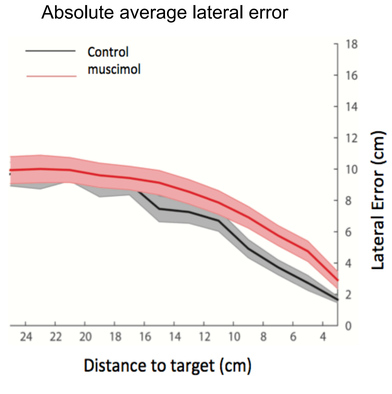
- Inhibition of SC resulted in a 4-fold increase in time to capture cricket



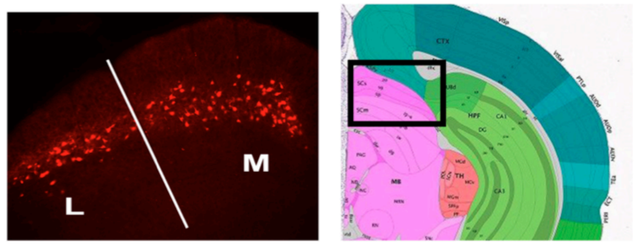
Inhibition of SC decreases accuracy of visually-mediated approach behavior



- Individual approach trajectories in terms of lateral error are shown in the top panels, grey are from control mice and red are from muscimol injected.
- The average approach paths in terms of lateral error are shown to the right. We see significant differences in where mice consistently decrease the error between their current head location and the target location.



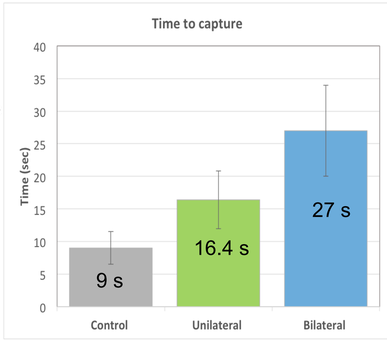
Targeted inactivation of wide field cells in SC



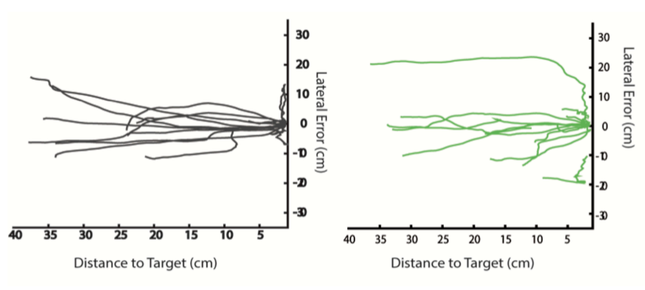
- We successfully infected WF neurons in the superior colliculus with inhibitory DREADDS as indicated by the red fluorescence shown above.
- WF neurons are localized to the intermediate layer of SC, which is where the red fluorescence is localized.
- n = 1 per condition: bilateral, unilateral, no inhibition

Inactivation of WF neurons impairs prey-capture

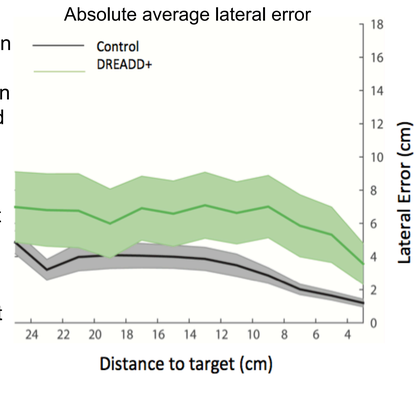
- Inhibition of increasing numbers of WF cells show stepwise increase in time to capture



Inactivation of WF cells decrease accuracy of visually-mediated approach



- Individual approach trajectories are again shown in the top panels, grey are from control mice and green are from mice with inhibited WF cells.
- The average approach paths to the right show that inhibition of a specific subset of SC neurons (WF cells) decreases the ability of mice to detect and orient towards prey.



Conclusions

- We have identified for the first time, a specific subset of neurons within superior colliculus that impair the visually-mediated aspects of prey-capture behavior in mice.
- We may now trace the connections of these neurons and monitor their activity during prey-capture behavior in order to learn more about how they process visual information to guide this important approach based behavior.

Future Directions

- Increase n in DREADD study and confirm the relevance of WF cell to mediating the visual aspects of prey capture behavior
- Further isolate stimulus features that drive visually guided approach behaviors and determine if WF cells process those features.
- Analyze head angles of approaches to clarify reorienting behavior and fully account for increases in capture times. This will further our understanding of what information the WF cells may specifically be involved in processing during this interesting behavior.

References

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- SC cat/mouse image from Comoli, E., Favaro, P.D.N., Vautrelle, N., Leriche, M., Overton, P.G. & Redgrave, P. Segregated anatomical input to sub-regions of rodent superior colliculus associated with approach and defense. *Frontiers in Neuroanatomy.* 1-19 (2012).

Acknowledgments

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